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ABSTRACT

The effectiveness of a basic college mathematics course consisting of lecture-discussion classroom procedures and homework assignments from a traditional text was compared to the effectiveness of a course designed to combat low grade achievement and a high dropout rate by allowing for individual differences. The revised course consisted of individual study using a programmed text, short discussion periods, and one-to-one student/teacher interaction. A total of 1,824 students had received traditional math instruction between 1968 and 1971 at Manatee Junior College (Florida) while 1,297 students had received the modified form of math instruction between 1972 and 1974. Random samples of 60 students from each of these groups were drawn and the average achievement of each group in basic mathematics compared. Results of the comparison indicated no significant differences in the performance levels or dropout rate of the two groups studied. Although the programmed text did not prove a cure for the problems of basic mathematics, it was found to be an equally effective learning device as lecture, and one which offered the instructor more flexibility in designing learning activities. (JDS)

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A COMPARISON OF GRADE ACHIEVEMENT OF STUDENTS USING A PROGRAMMED MATHEMATICS TEXT VERSUS STUDENTS USING A TRADITIONAL MATHEMATICS TEXT

by

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STATEMENT OF THE PROBLEM

This study is an investigation and analysis of two types of learning activities used in a basic mathematics course at Manatee Junior College. The learning activities were designed around two distinct mathematics texts: (1) an elementary text[2] written in a linear programmed format and (2) an elementary text[1] written in a traditional format.

The traditional text[1] was used in all sections of the general education mathematics courses at Manatee Junior College during the academic years 1968-69, 1969-70, and 1970-71. The learning activities consisted of lecture-discussion classroom procedures and homework assignments covering the exercises included in the book. The student's grade was based upon the scores obtained on six one-hour tests and a final examination. The final exam constituted approximately one-fourth of the final grade. Some of these classes met for fifty three minutes on Monday, Wednesday, and Friday and others were conducted for one hour and twenty minutes on Tuesday and Thursday. Regardless of the meeting date, however, each class was required to exhibit proficiency in the same concepts. To further insure that all sections of this course (Math 101) obtained the same performance levels, exams were conducted by the mathematics

department as a whole rather than by the individual instructors of the various sections.

The programmed text[2] was used in all sections of the general education mathematics courses at Manatee Junior College during the academic years 1971-72, 1972-73, and 1973-74. As was the case with the classes conducted with the traditional text, some of the classes met for fifty three minutes on Monday, Wednesday, and Friday and others met for one hour and twenty minutes on Tuesday and Thursday. Regardless of the meeting schedule, all classes were required to exhibit competency in the same concepts. The classroom learning activities using the programmed text[2] consisted of (1) a short discussion period, (2) a brief ten-question quiz, and (3) an individual study period in which the teacher could discuss problems with the students on a one-to-one basis. The student's grade was determined by his performance on twenty seven quizzes and a final exam. The final exam was comprehensive in nature and accounted for one-fourth of the final grade. All quizzes and examinations were the result of a departmental effort, rather than being constructed by the individual section teachers.

The course content (basic algebra) was the same in both of the texts used. Also there was no difference in the performance objectives of the two approaches.

The prerequisite of at least one year of high school

algebra was constant throughout the 1968-73 time span. The course (Math 101) was the minimum mathematics requirement at Manatee Junior College and hence a broad section of students is represented. The scope of this problem is to study the grade achievement of all students who registered for Math 101 during the 1968 to 1973 time interval.

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[1]Thomas L. Wade and Howard E. Taylor, Fundamental Mathematics (New York: McGraw-Hill, 1956)

[2]J. Bryan Sperry, Programmed Algebra (Boston: Holbrook Press, 1970)

HYPOTHESIS

There is no significant difference in the mean grade, U2, of group II and the mean grade, U1, of group I.

Null Hypothesis, H1: $U2 = U1$

Alternative Hypothesis, H2: $U2 \neq U1$

BACKGROUND AND SIGNIFICANCE

At Manatee Junior College the minimum mathematics requirement for all transfer programs is "mathematics for general education" (Math 101). This requirement for a broad range of programs results in a very diversified composition of students in Math 101. This diversification can be found in the areas of ability, interest, academic background, sex, age, and socio-economic background. It is the opinion of the mathematics department, that this situation creates special learning problems because of the wide individual differences. This concern is also shared by Roueche (1973, Chapter 1) and Moore (1970, Chapter 1).

Prior to the fall semester of 1968, the content of the Math 101 consisted of cultural topics that were currently being produced in the commercial textbooks. It was decided in the fall of 1968, due to low grade achievement, that a different approach should be used. A traditional text[1] in both content and exposition was selected for use beginning in the fall semester of 1968. The classes were conducted in the traditional lecture format. Students were expected to learn by observing material presented during the lectures and to reinforce this learning by doing the exercises assigned in

the text. Although experience with Math 101 has shown this approach to be of questionable value, it is an assumption shared by others (Lindgren, 1969), and it was used as our working hypothesis. The high drop-out rate and low-grade achievement caused the mathematics department to abandon this approach in the fall of 1971.

A new approach was sought to encourage more self-involvement, as described by Lindgren (1969, PP. 30-34), on the part of the student. This approach should allow as much as possible for individual differences and it had to be done with a class size of thirty to forty students. Budget limitations also required that an approach be developed without any significant increase in cost for personnel or equipment. However, these constraints were not used as excuse for "not getting the job done." As pointed out by Mayhew (1971, PP. 97), unproductive methods of instruction are too great an extravagance for even a wealthy nation like the United States.

A programmed text[2] with the same mathematical content as the previous traditional text[1] was selected as the foundation for this new approach. With this text it was anticipated that some allowance for individual differences, as described by Moore (1970) and Roueche (1972), could be made. Instead of using the entire class period for lectures and group discussion, the class activities consisted of a short discussion, a brief quiz, and the remainder of the time was devoted to

individual study and tutorial help by the instructor. This allowed, to some degree, for each student to zero in on his specific problem area. The primary expectation of this new approach was a lowering of the drop-rate. However, at this point in time no comprehensive study has been made of this expectation. Also, no study has been made of the grade achievement of these two groups of students. Corn (1973) did a subjective study of the use of a programmed text in basic algebra at Queensborough Community College, but there was no comparison with classes using a traditional text. Roueche (1973) indicates that an individualized approach, that would be allowed by our use of a programmed text, is more productive than the traditional lecture method. This study is an attempt to test that hypothesis in the setting of the general education mathematics course at Manatee Junior College.

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[1]Thomas L. Wade and Howard E. Taylor, Fundamental Mathematics (New York: McGraw-Hill, 1956)

[2]J. Bryan Sperry, Programmed Algebra (Boston: Holbrook Press, 1970)

DEFINITION OF TERMS

I. Math 101: A general education mathematics course at Manatee Junior College--the minimum mathematics requirement for all degree candidates.

II. Traditional Lecture Format: A class in which the majority of class time is used for lecturing by the instructor.

III. Traditional Text: A mathematics text in which the structure consists of an exposition on a given concept followed by a set of exercises to be performed by the reader.

IV. Programmed Text: A mathematics text written in the linear programming format.

V. Class Period: A single class meeting of either fifty three minutes or eighty minutes.

VI. Learning Activities: The means by which a student achieves the objectives of a course.

VII. Significant Difference: The probability that the occurrence of an event is greater than 5%.

VIII. Group I: The Math 101 students using the traditional text.

IX. Group II: The Math 101 students using the programmed text.

LIMITATIONS

It is recognized that certain variables relating to internal validity cannot be controlled in this study. These variables as described by Campbell (1966) are: history, maturation, instrumentation, and selection-maturation interaction. Although these variables are not controlled, the study is being made in a real setting and it is expected that the results will be meaningful. Also, there is some reservation about extending the findings of this research to other institutions. It could be that these results may be valid only in the philosophical setting of the present mathematics department at Manatee Junior College.

BASIC ASSUMPTIONS

I. Both groups being studied are homogenous.

II. Both groups being studied have intelligence scores that are distributed normally.

III. Both groups being studied were expected to achieve the same performance objectives.

IV. The instructors in both groups used approximately the same teaching methods.

V. The time of day in which the class meets is an insignificant variable.

VI. There is no significant difference between student achievement during the spring and fall semesters.

VII. The grades for each of the three year study periods are normally distributed.

PROCEDURES FOR COLLECTING DATA

The information gathered for this study consisted of the final grades achieved in Math 101 for group I and group II. This data was stored on computer tape and retrieved by a random number generating function. The FORTRAN program for producing this function is contained in the Appendix. This program randomly selected students from group I and group II according to their student numbers. However, for the purpose of clarity, the students selected have been displayed according to their alphabetical rank in the class.

Since the computer system at Manatee Junior College does have the capability of retrieving only one specified bit of information, it was necessary to retrieve the complete academic record of each student sampled. It was anticipated that these record would contain the test scores showing the verbal and quantitative abilities of the students samples. However, all students did not take the same ability tests and some had no test scores at all. This precluded the "ability comparison" of the two groups studied.

There were 1824 students in group I and 1297 students in group II. A random sample of sixty students was selected from each of these groups. The computer was programmed to select

a random sample of ten students from each of the six semesters spanned during the time interval of each of the two groups. The procedure used for selecting a specific set of ten students from a given semester was to first, randomly select a section of Math 101 and second, randomly select a student from that section.

These random samples were used to construct a frequency distribution for group I and a frequency distribution for group II.

PROCEDURES FOR TREATING DATA

The data is first displayed in the raw form as obtained from the random sampling procedures. It is then displayed in the form of frequency distributions and histograms.

The hypothesis is tested using the F-distribution as defined by Yamane (1964, Chapter 21). This testing procedure requires a significance test of the variances of the two sample groups before proceeding with the testing of the means of the two groups. Therefore, a null hypothesis comparing the variances of the two groups is defined and tested. Following this prerequisite test, the significance of the means of the two population groups being implied by the means of the sample groups is tested.

DATA RESULTING FROM THE STUDY

The students selected as the random samples are exhibited in the form of ordered pairs. The first component of the ordered pair represents the section number of Math 101 selected and the second component represents the alphabetical rank of the student selected from that section. The samples are displayed according to the semesters in which the sets consisting of ten students each were selected.

Group I Sample

Fall Semester, 1968: [2,14], [10,16], [1,27], [7,4], [6,4], [4,30], [2,9], [6,36], [7,41], [1,25].

Spring Semester, 1969: [1,40], [2,23], [1,2], [3,25], [2,37], [5,37], [1,8], [1,7], [3,22], [5,22].

Fall Semester, 1969: [1,14], [5,37], [8,16], [9,32], [9,39], [6,30], [7,32], [4,32], [1,35], [4,42].

Spring Semester, 1970: [5,33], [1,33], [2,14], [4,4], [4,6], [6,31], [1,40], [3,39], [4,2], [5,39].

Fall Semester, 1970: [1,37], [2,29], [1,42], [7,6], [5,42], [4,7], [3,33], [6,14], [5,26], [7,27].

Spring Semester, 1971: [2,4], [5,34], [4,15], [4,33], [7,6], [2,5], [5,21], [6,7], [3,24], [7,11].

Group II Sample

Fall Semester, 1971: [8,27], [2,1], [2,13], [4,30], [6,6], [6,7], [5,20], [2,24], [4,43], [1,8].

Spring Semester, 1972: [2,29], [6,3], [4,40], [4,1], [1,17], [5,8], [3,37], [6,25], [1,16], [1,10].

Fall Semester, 1972: [4,15], [7,10], [6,6], [3,5], [6,10], [1,7], [3,4], [7,14], [1,25], [3,19].

Spring Semester, 1973: [1,33], [1,40], [3,34], [1,14], [5,34], [3,6], [5,37], [4,14], [3,8], [4,27].

Fall Semester, 1973: [5,33], [3,11], [3,13], [1,25], [3,3], [4,10], [3,21], [1,19], [5,21], [4,39].

Spring Semester, 1974: [4,1], [1,7], [4,30], [1,4], [2,35], [2,38], [4,35], [2,36], [2,9], [1,30].

Grade Distribution Tally of Group I Sample

Semester	A	B	C	D	F	W
Fall, 1968	2	2	1	2	0	3
Spring, 1969	0	1	4	2	0	3
Fall, 1969	0	2	0	0	2	6
Spring, 1970	0	3	1	2	1	3
Fall, 1970	3	1	3	1	2	0
Spring, 1971	0	2	2	2	1	3

Grade Distribution Tally of Group II Sample

Semester	A	B	C	D	F	W
Fall, 1971	1	2	3	0	0	4
Spring, 1972	1	2	3	1	0	3
Fall, 1972	2	1	5	1	0	1
Spring, 1973	0	1	2	1	1	5
Fall, 1973	0	1	2	3	1	3
Spring, 1974	0	2	4	0	0	4

SIGNIFICANCE OF THE DATA

For meaningfulness and interpretation the data collected from the group I and group II samples are displayed as frequency distributions and as histograms. In order to facilitate the statistical analysis of this data, the following symbolism has been used:

x_i: The grade points assigned to a particular letter grade.

f_i: The frequency of occurrence of a given grade.

$\overline{x_i}$: The mean grade point of the i^{th} sample group.

u_i: The mean grade point of the i^{th} population group.

$\hat{\sigma}_i$: The standard deviation of the i^{th} sample group.

σ_i: The standard deviation of the i^{th} population group.

n_i: The sample size of group i.

$S_i^2 = \left(\sum_{k=1}^{n_i} (\overline{x_i} - x_k)^2 \right) \div n_i$, where i denotes the sample group number.

F: The F statistic computed from the sample variances.

$F^{\phi_1}_{\phi_2}$: The F score for the F-distribution with ϕ_1 degrees of freedom in the numerator and ϕ_2 degrees of freedom in the denominator.

t: The t statistic for the t distribution.

Since students may withdraw from a class as late as two weeks before the final exam, the grades of F and W have both been assigned a grade point of zero. This convention has been adopted because under the present grading policy, both grades represent a lack of success in passing the course.

Frequency Distribution of Group I Sample

Grade	Grade Points (x_i)	Frequency (f_i)	$f_i \cdot x_i$	$f_i(\overline{x_1} - x_i)^2$
A	4	5	20	33.8
B	3	11	33	28.16
C	2	11	22	3.96
D	1	9	9	1.44
F,W	0	24	0	47.04
		$\sum$ =60	$\sum$ =84	$\sum$ =114.4

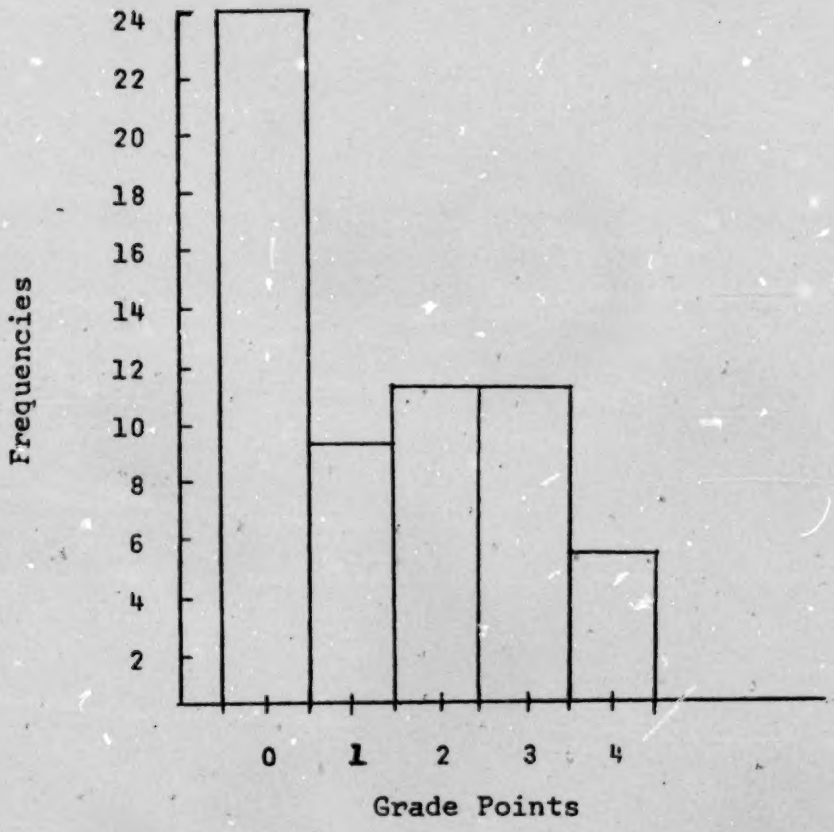
$\overline{x_1} = \frac{84}{60} = 1.40$

Frequency Distribution of Group II Sample

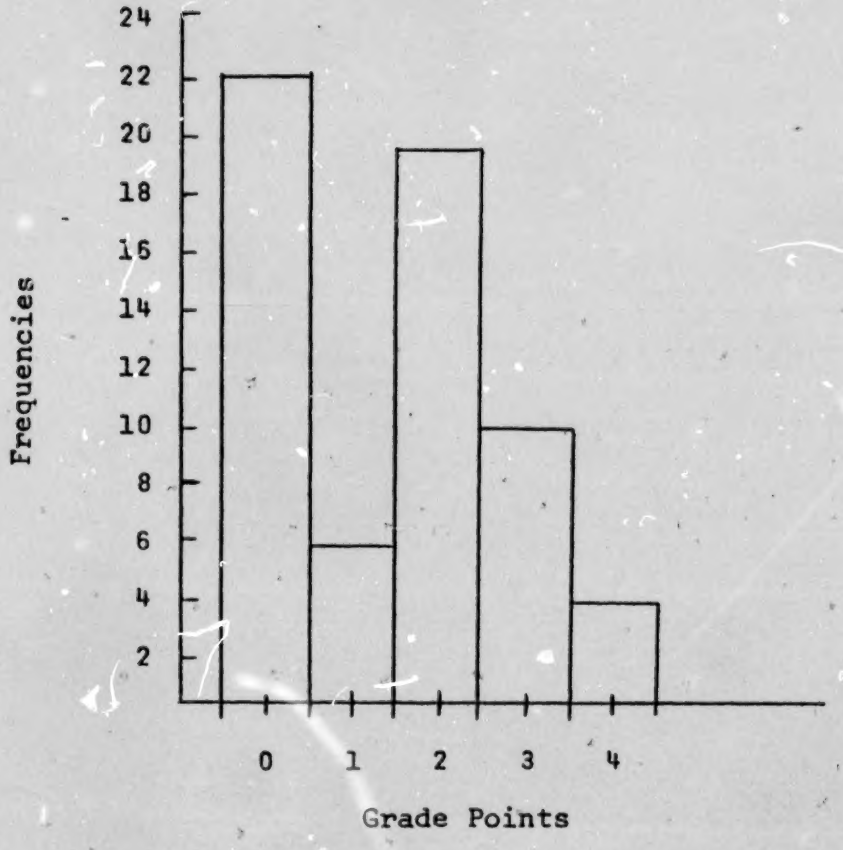
Grade	Grade Points (x_i)	Frequency (f_i)	$f_i \cdot x_i$	$f_i(\overline{x_2} - x_i)^2$
A	4	4	16	26.01
B	3	9	27	21.6225
C	2	19	38	5.7475
D	1	6	6	1.215
F,W	0	22	0	46.255
		$\sum$ =60	$\sum$ =87	$\sum$ =100.85

$\overline{x_2} = \frac{87}{60} = 1.45$

Histogram For Group I Sample



Histogram For Group II Sample



As stated by Yamane (1964, P. 658), the F-distribution can be used to compare two population means only if the population variances are equal. Therefore, before proceeding with the comparison of the population, the significance of the difference of these variances is tested.

Null Hypothesis: $\sigma_1^2 = \sigma_2^2$

Alternative Hypothesis: $\sigma_1^2 \neq \sigma_2^2$

Test $\hat{\sigma}_1^2 = \hat{\sigma}_2^2$.

From the frequency distributions:

$$\hat{\sigma}_1^2 = \frac{114.4}{59} = 1.93983 \quad \text{and} \quad \hat{\sigma}_2^2 = \frac{100.85}{59} = 1.709332.$$

Hence, $F = \dfrac{\hat{\sigma}_1^2}{\hat{\sigma}_2^2} = \dfrac{1.93983}{1.709332} = 1.134513.$

Using a two-tail test, when $\frac{a}{2} = 2.5\%$ and (59,59) degrees of freedom we have:

$$F_{59}^{59} = 1.6735.$$

Therefore, $F = 1.134351 < F_{59}^{59} = 1.6735$.

Hence, $F = 1.134351$ is not significant and the hypothesis that $\sigma_1^2 = \sigma_2^2$ is accepted.

Now the hypothesis that $U_1 = U_2$ is tested. First the t statistic is calculated:

$$t^* = \frac{(\overline{x_1} - \overline{x_2})\,(n_1\, n_2)\,(n_1 + n_2 - 2)}{(n_1\, s_1^2 + n_2\, s_2^2)\,(n_1 + n_2)}$$

$$= \frac{(1.45 - 1.40)\ (60 \times 60)\ (60 + 60 - 2)}{(114.4 + 100.85)\ (60 + 60)}$$

$$= \frac{(.05)\ (3600)\ (118)}{(215.25)\ (120)}$$

$$= \frac{21,240}{25,830}$$

$$= .8222996.$$

Using a one-tail test for a = 5% and (1,58) degrees of freedom,

$$F_{58}^{1} = 4.015.$$

Therefore, $t^2 = .822996 < F_{58}^{1}$, is not significant and the hypothesis that $U_1 = U_2$ is accepted.

CONCLUSIONS AND SIGNIFICANCE

The primary conclusion that can be drawn from this study is that there is no difference in the performance level of the two groups studied. This is verified by the fact that the variances as well as the means of the two groups were the same.

These findings indicate, in the context of basic mathematical concepts, that a programmed text can serve the student just as effectively as the lecture in imparting basic concepts. With this tool available for teaching basic facts, the instructor would have the opportunity to embellish the content of the course. The instructor will also be able to give serious consideration to each student's learning style, study habits, and rate of progress daily. There may also be an opportunity to try and improve the students attitudes toward math.

In summary, this study indicates that the programmed mathematics text is no magic cure for the ills of basic mathematics students. However, concerning basic skills, it is an effective learning device that offers the instructor more flexibility in designing the learning activities for the class.

FURTHER STUDIES

The high number of F and W grades for the groups studied indicate that a study of the placement of students in Math 101 should be undertaken. This study should consist of an examination of the academic background of the Math 101 students and the advisement techniques used in placing students in Math 101.

Class size may also be a factor in the lack of success of the Math 101 students. There should be some investigation of the success of large classes as compared to the success of smaller classes. Also, to place the performance of the Math 101 students in proper perspective, they should be compared with the performance in other general education courses such as English, basic science, history, and political science.

APPENDIX

```
C FUNCTION TO PRODUCE 9-DIGIT RANDOM NUMBER
      FUNCTION RNG(N)
      N3=N*3
      N2=N*2
    3 IF(N3-999999883) 7,7,5
    5 N3=N3-999999883
      GO TO 3
    7 IF(N2-999999893) 9,9,8
    8 N2=N2-9999998983
      GO TO 7
    9 N=N2+N3
      IF(N-999999999) 11,11,10
   10 N=N-999999999
   11 RETURN
C  THE VALUE RETURNED FROM EACH USE OF THE FUNCTION
      SHOULD BE THE ARGUMENT
C  FOR THE NEXT USE
```

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